Pressure and Quantity Thresholds for Ignition of Oil Contamination by Rapid Pressurization in Oxygen Systems

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July 2009

Problem Statement

- Problem:
  - Oil contamination produces an increased ignition hazard in oxygen systems
- Solution:
  - Determine oil quantity and oxygen pressure thresholds

Experimental

- Perform rapid pressurization tests
  - Common ignition mechanism in oxygen systems
- Contamination level threshold
  - Determine quantity of oil (sebum) deposited by handling hardware with bare hands
  - Determine quantity of oil (sebum) required to obtain a burning reaction during rapid pressurization to 4000 psi
- Oxygen pressure ignition threshold
  - Use highly volatile hydrocarbon oil (WD-40) on open-cell polyethylene foam
  - Determine minimum ignition threshold as a function of pressure

Contamination Level Threshold

- The oil on the surface of the skin is a complex mixture of sebum oil, lipids, sweat, and environmental materials
- Synthetic sebum selected for tests

TABLE 1—*Composition of synthetic sebum (Lot #9183).*[a]

	Composition
10 %	Palmitic acid
5 %	Stearic acid
15 %	Coconut oil
10 %	Paraffin wax
15 %	Synthetic spermaceti
20 %	Olive oil
5 %	Squalene
5 %	Cholesterol
10 %	Oleic acid
5 %	Linoleic acid

[a]Synthetic sebum is a product of Scientific Services S/D, Inc., 42 Main Street, Sparrow Bush, NY, 12780. (Treated to remove peroxides and flushed with nitrogen in order to prevent polymerization and oxidation; contains trace water; is stable at ambient conditions in the absence of air; nitrogen padded.)

Contamination Level Threshold

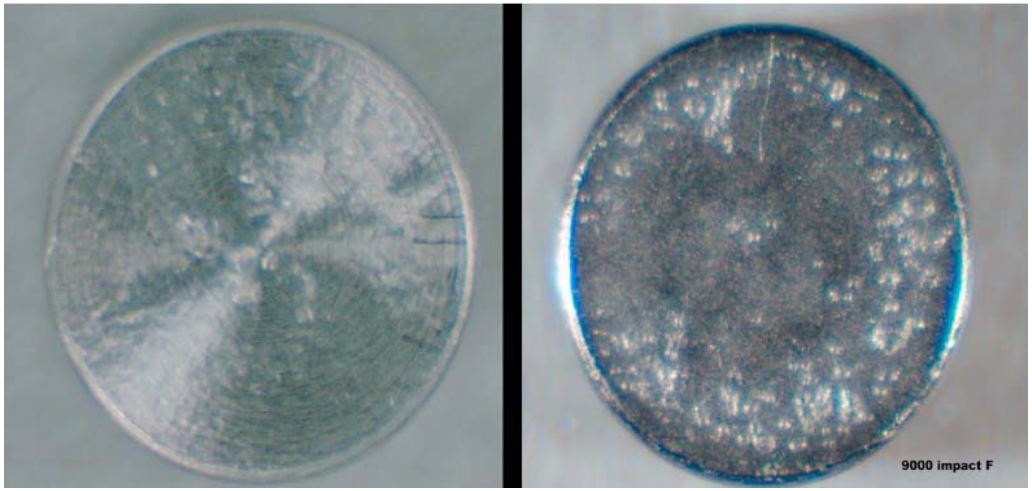
- Properties of sebum oil
  - Heat of Combustion
    - ~39.7 KJ/g
    - 90% of hydrocarbon-based oil
  - Auto Ignition Temperature
    - 139 ± 7 ºC
    - Silicone grease AIT = 216 ºC

Contamination Level Threshold

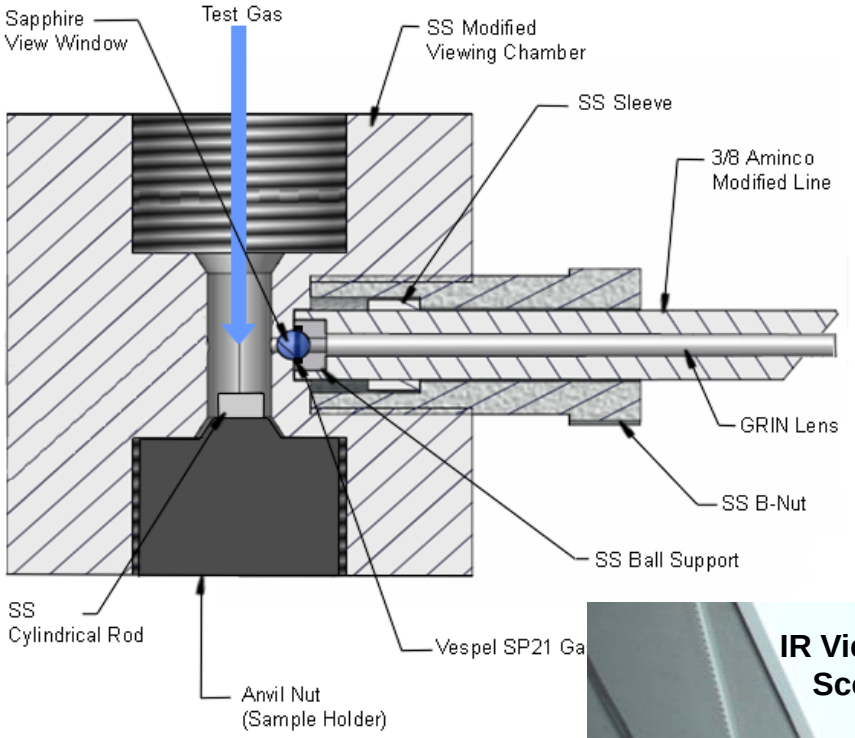
- Evaluated contamination level due to handling without gloves
  - Five technicians
  - Four separate occasions
  - “Flip & Grip” test coupons
  - NVR = 14 ± 5 mg/m^2

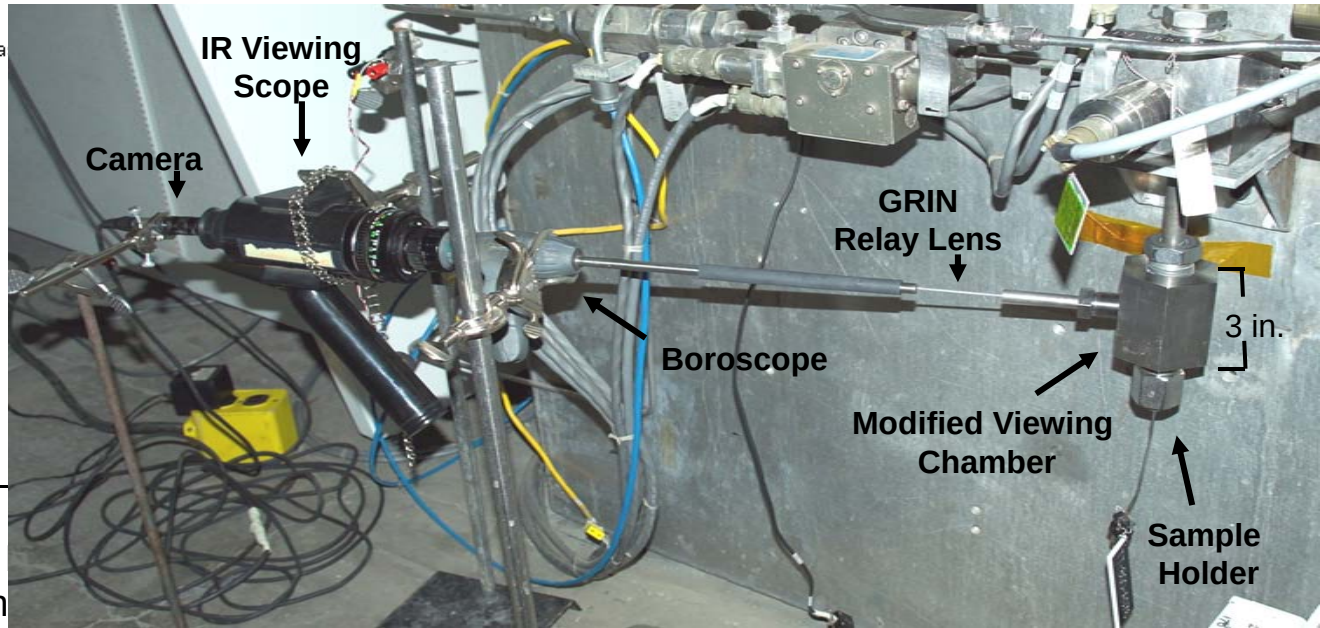
Contamination Level Threshold

- Rapid pressurization according to ASTM G74
- Oil coated cylindrical rods
- Varied surface concentration (9000 mg/m^2)
- Tested at 4000 psi (27.6 MPa)



Detection Technique





Contamination Level Threshold

- Threshold surface concentration was 150 mg/m^2
- Next highest concentration tested was 340 mg/m^2
- Hand oil contamination maximum 20 mg/m^2

Contamination level (mg/m^2)	Number of reactions/ number of tests
9,000	1/3
3,200	1/12
540	1/27
340	1/16
150	0/40

Oxygen Pressure Level Threshold

- Rapid pressurization according to ASTM G74
  - Each sample subjected to 5 consecutive pneumatic impact events for each test data point
- Minicell L-200 polyethylene foam samples
- Contaminated with WD-40
- Tested at various oxygen pressures

Oxygen Pressure Level Threshold

- A reaction occurred at 300 psia
- No reactions occurred at 275 psia in 80 tests

Impact Pressure		Number of Reactions	Number of Samples Tested
(Mpa)	(psia)		
2.4	350	1	20
2.1	300	0	20
2.1	300	1	4
1.9	275	0	20
1.9	275	0	20
1.9	275	0	20
1.9	275	0	20

From WSTF Number 06-40281

Summary

- Contamination level threshold
  - Sebum (fingerprint) oil
  - 4000 psi rapid pressurization
  - Between 150 and 340 mg/ft^2
  - Fingerprints could contribute to other oil contamination
- Oxygen pressure level threshold
  - WD-40 oil
  - Standard rapid pressurization test system
  - Between 275 and 300 psia
  - Below 275 psia (minus your desired margin) no ignition due to rapid pressurization